

# EUV Related Work at L-3 Integrated Optical Systems

EUV Lithography Symposium

Maui, HI

Date: June 12<sup>th</sup>, 2013

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# Agenda

1. Introduction to L-3 Integrated Optical Systems
2. Metal Optics, Advantages & Performance
3. IR Rejection EUV Collector Technology

# L-3 Integrated Optical Systems (IOS)

*Expertise of three heritage optics companies combined into one seamless division providing electro-optical sensors, subsystems, and components*

Wilmington, Ma



Richmond, Ca



Pittsburgh, Pa



## Wilmington Facility

- Space telescopes
- LOS pointing mirrors
- Fast steering mirrors
- Airborne optical systems
- SiC systems
- Hyperspectral systems
- Optical sensor assemblies



## Richmond Facility

- Engineered optical solutions
- Aspheric optical fabrication
- Unique metrology capabilities
- Wide range of material offerings



## Pittsburgh Facility

- Ground telescopes
- Beam control systems
- Large gimbal systems
- Large optical components
- Fire control systems



- **400 employees**
- **250,000 square feet of facilities in MA, PA, and CA**
- **10,000 square feet of cleanroom space**
- **Full design, analysis, manufacture, assembly, test**
- **End-to-end manufacturing and test facilities**
- **ISO 9001:2008 Certified**

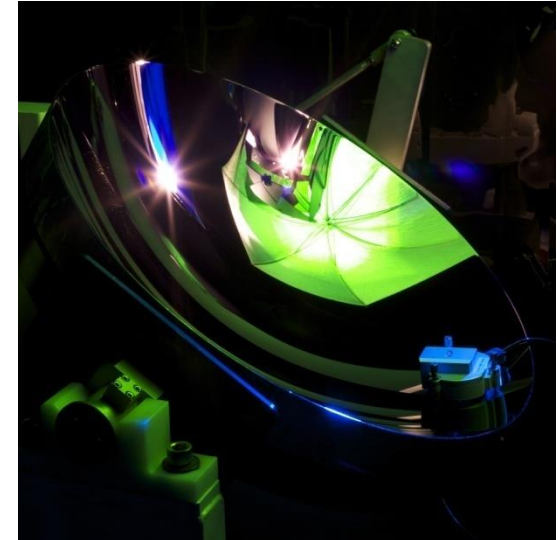
Applications: Illumination and Inspection

# **METAL OPTICS SURFACE FINISH**

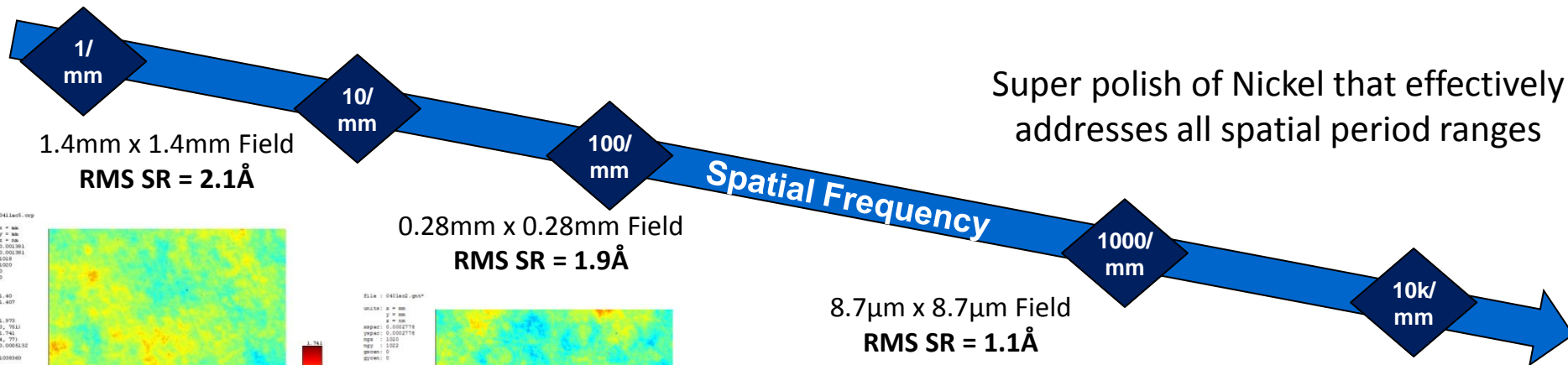
# Advantages of Metal Optics

Electroless-Nickel Plated Optics  
Offer Many Advantages:

- Lower Cost
- Shorter Lead-time
- Ease of Cooling Integration
- Broad Supporting Supply Base
- Range of Substrate Materials and Properties



# Super Polish of Nickel

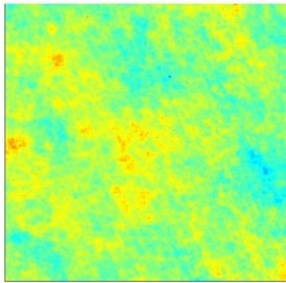


Super polish of Nickel that effectively addresses all spatial period ranges

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z-map: 1.40  
z-rms: 1.407  
z-ptv: 3.714  
z-rms: 0.2072



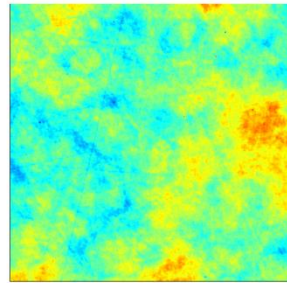
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0.28mm x 0.28mm Field  
RMS SR = 1.9Å

File : 0410a01.gpn

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zunit: 0.0002778

z-map: 1.40  
z-rms: 1.407  
z-ptv: 3.714  
z-rms: 0.2072



Traditional Comments: "this file = original - 0410a01.gpn"

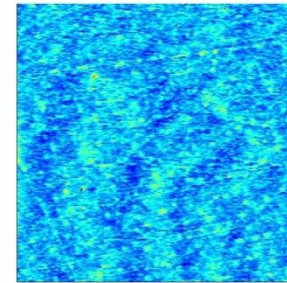
**Spatial Frequency**

8.7μm x 8.7μm Field  
RMS SR = 1.1Å

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z-ptv: 3.714  
z-rms: 0.2072



Traditional Comments: "this file = original - 0410a01.gpn"

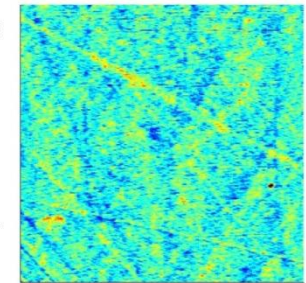
1000/ mm

2.2μm x 2.2μm Field  
RMS SR = 0.8Å

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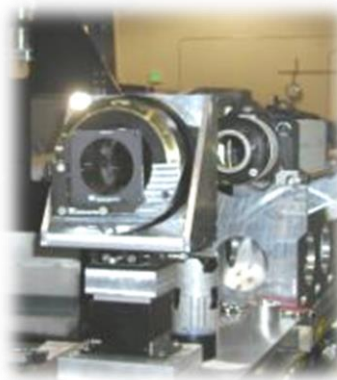
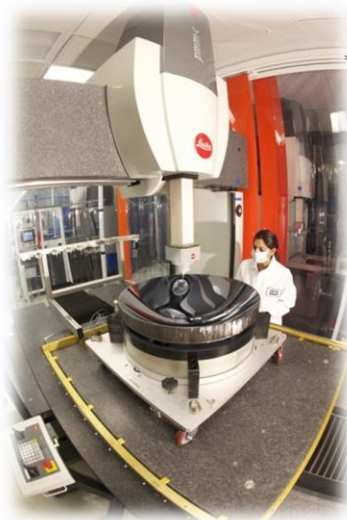
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yunit: 0.00025  
zunit: 0.00025

z-map: 1.40  
z-rms: 1.407  
z-ptv: 3.714  
z-rms: 0.2072



Traditional Comments: "this file = original - 0410a01.gpn"

10k/ mm

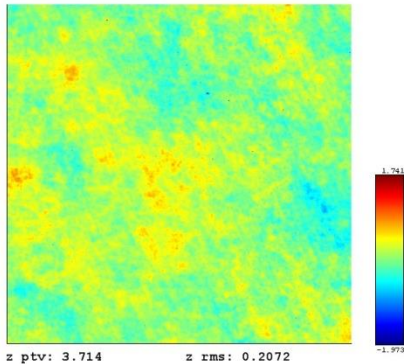




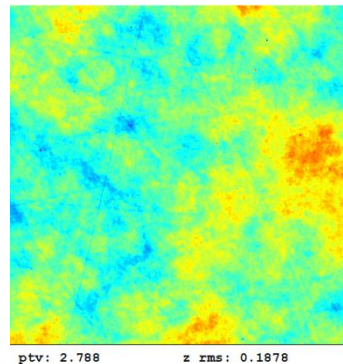
# Nickel vs. Polycrystalline Silicon

1.4mm x 1.4mm Field  
RMS SR = 2.1Å

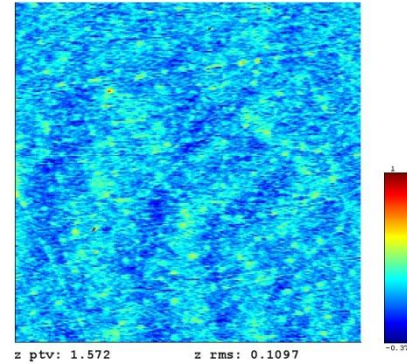
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ymag: 1.407  
zmag: 1.407  
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x max: 1.741  
y min: -1.741  
y max: 1.741  
z min: 0.0008232  
z max: 1.038260  
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xval: 0.002



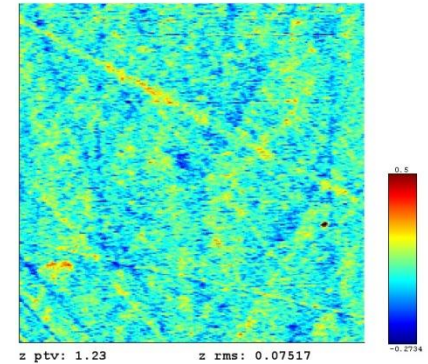
0.28mm x 0.28mm Field  
RMS SR = 1.9Å



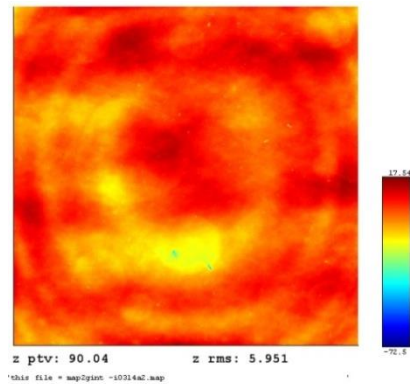
8.7μm x 8.7μm Field  
RMS SR = 1.1Å



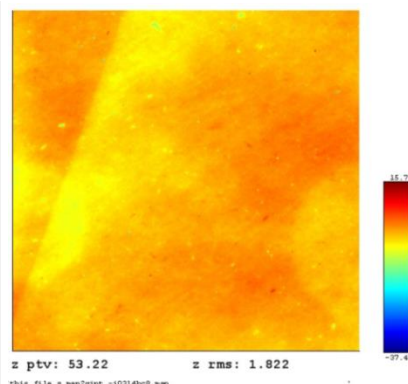
2.2μm x 2.2μm Field  
RMS SR = 0.8Å



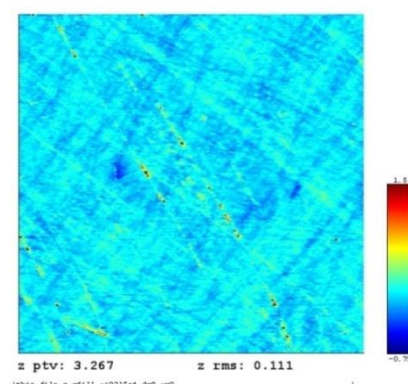
1.4mm x 1.4mm Field  
RMS SR = 5.9Å



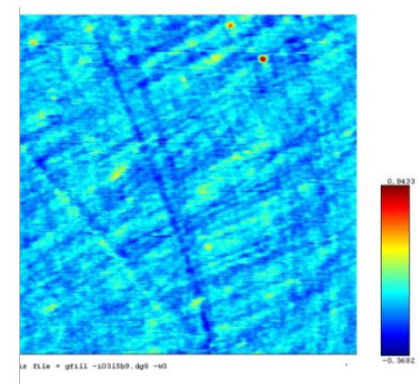
0.28mm x 0.28mm Field  
RMS SR = 1.8Å



8.7μm x 8.7μm Field  
RMS SR = 1.1Å

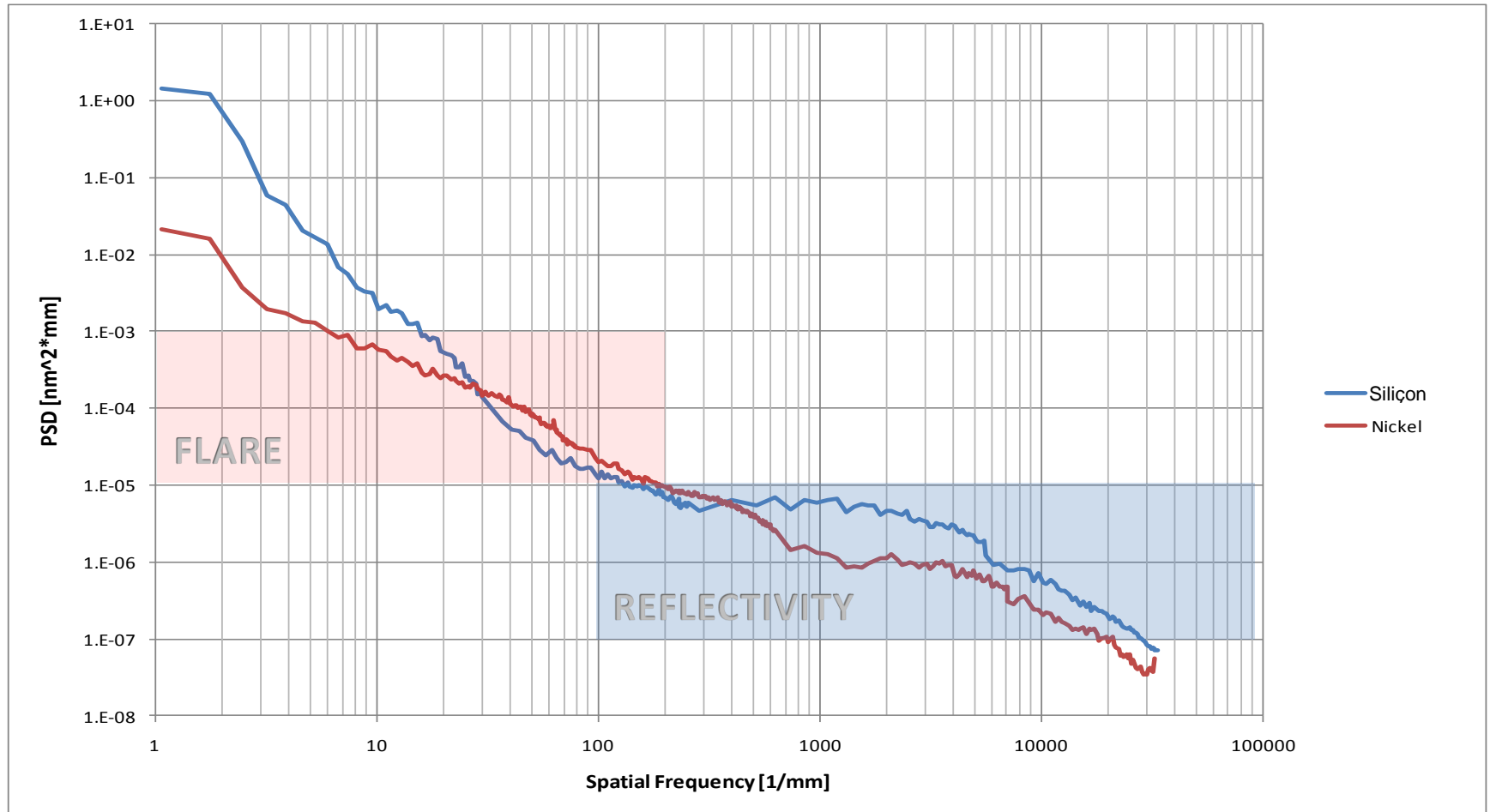


2.2μm x 2.2μm Field  
RMS SR = 0.9Å



# Surface Finish PSDs

Electroless Nickel vs. Poly-Crystalline Silicon

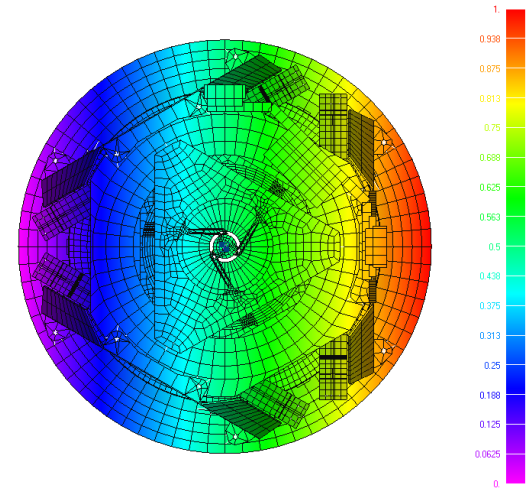




# Application to Schwarzschild Objective

Electroless nickel-plated aluminum is a viable alternative to low-expansion glass for some applications

- Prototype and Proof-of-Concept Systems
- Systems with tight constraints on cost and schedule



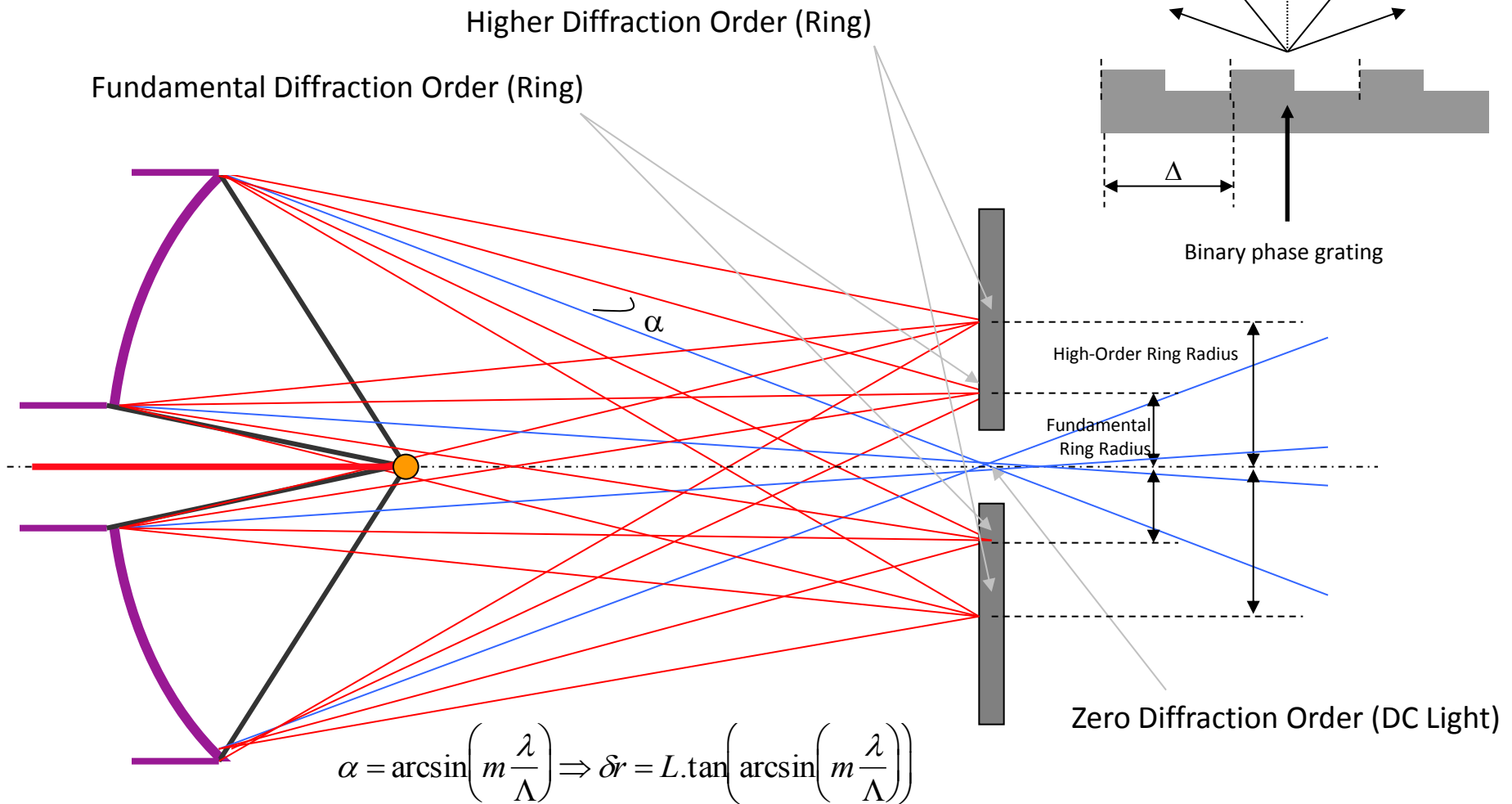
Description	Original Design (Hz)	All Aluminum Design (Hz)	Frequency Change
Hexapod Legs Twisting	92 (2X), 94	68 (2X), 70	-25%
Fold/DMI Assy Swaying	181, 183	120 (2X)	-34%
Lower Shroud Plunging	194	197	+2%
Connector Mount Bending	225 (3X)	232 (3X)	+3%
M1 Bipod Legs Twisting	267(6X)	317 (3X), 318 (3X)	+19%
Fold/DMI Assy Twisting	296	211	-29%
Lower Shroud Rocking	307 (2X)	314 (2X)	+2%
M1 Swaying	>328 Hz	227, 228	> -30%

Application: EUV Source Development

# **EUV COLLECTORS WITH IR REJECTION**

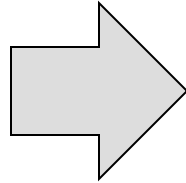
# IR Rejection Technology

*Binary Grating Diffracts 10.6μm Light into Rings*

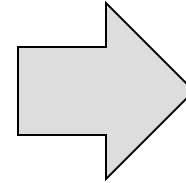


# IR Rejection Manufacturing Process

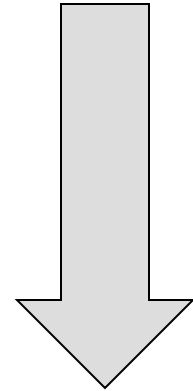
Fabricate  
Substrate



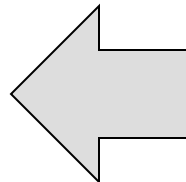
Electroless  
Nickel Clad  
Substrate



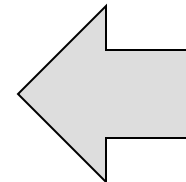
Diamond Turn  
Grating



Final Metrology

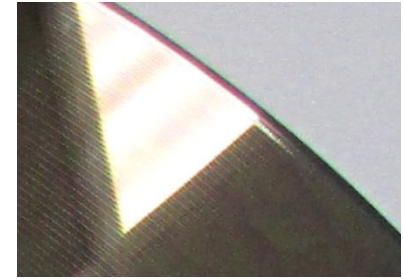
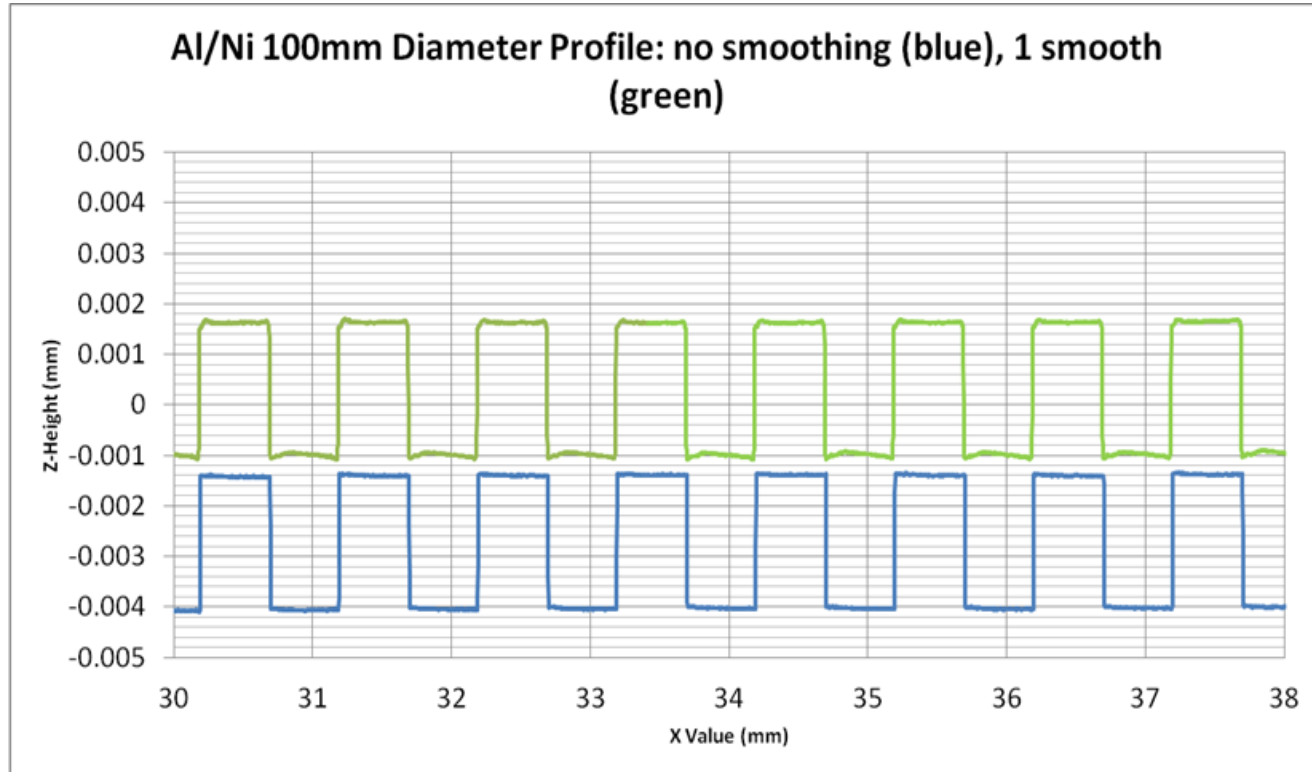


Smoothing



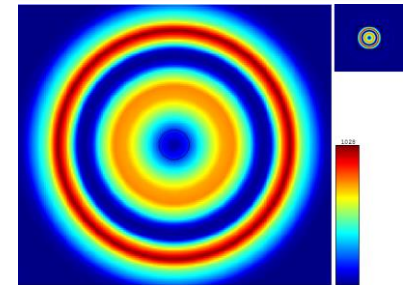
Verify Profile &  
IR Rejection

# Groove Profile



Grating Structure

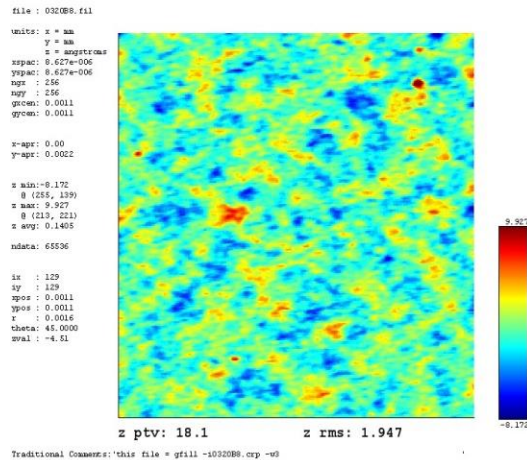
IR Diffraction



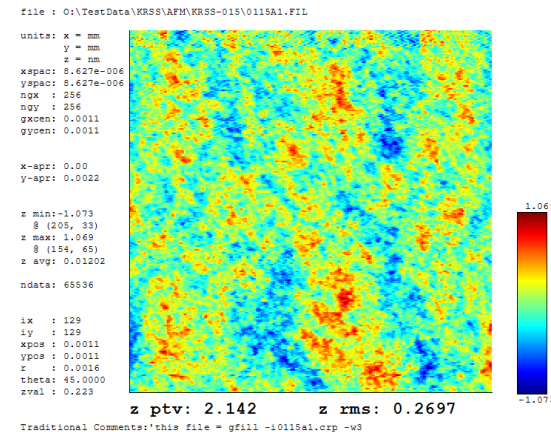
Groove profile provides 99.8-99.9% IR rejection



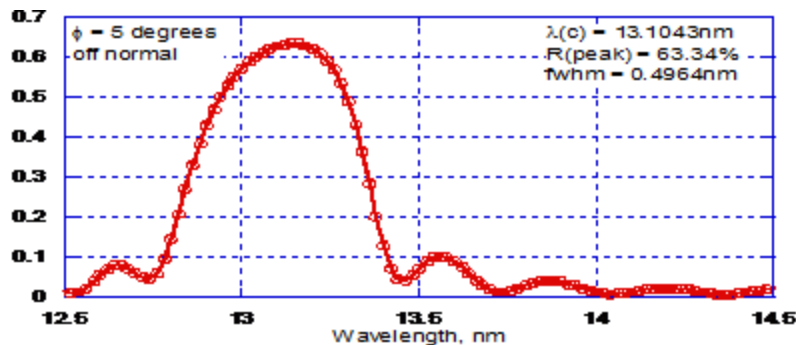
# IR Rejection Surface Roughness



1.9Å, 2.2μm x 2.2μm AFM Field



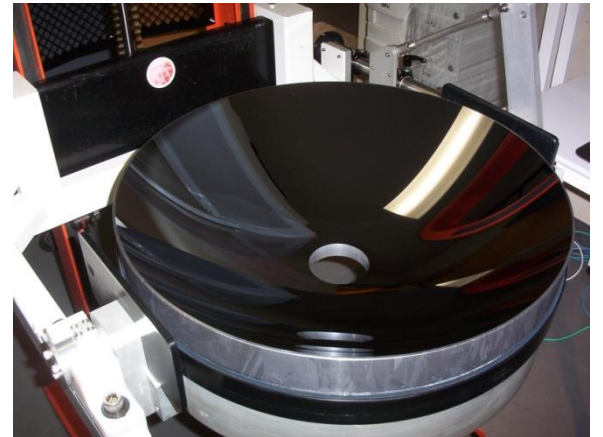
2.7Å, 2.2μm x 2.2μm AFM Field



- Smoothing process effectively integrates diamond turning structure
- Resulting surface roughness is uniformly below 3Å RMS
- Surface roughness consistent with  $\lambda = 13.4\text{nm}$  reflectivity of 60%

# EUV Project History

- Exitech Mask Inspection Tool
- Poly-Crystalline Silicon EUV Collectors
- Nickel Plated Aluminum EUV Collectors
- Schwarzschild Objective
- IR Rejection EUV Collectors



# Summary

- L-3 Integrated Optical Systems has novel finishing technologies which support EUV applications
- Engineered Optical Solutions
  - Metal Optics Replace Traditional Materials
  - IR Rejection for EUV Sources

**Dr. Jay Daniel**, Director of Advanced Programs and Technology

**Dr. Ulrich Mueller**, Electronics and Controls Engineering Manager

**Mr. Clay Sylvester**, Director of Sales and Contracts



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